NIST Greenhouse Gas and Climate Science Measurements Program Overview

Overview

Test Beds Advancing Urban Greenhouse Dome Measurement System Development

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Measurements Supporting Independent Verification of Greenhouse Gas Inventories

Measurement results and methodologies independent of the source can be a means to lend confidence to values provided by individual sources or sinks (bottom-up).

- Improved Top-Down methods, direct atmospheric observations, to independently verify self-reported emissions data.
- These methods are promising technologically but require substantial development and demonstration to achieve the scientific veracity & performance needed at urban & local scales.

GHG Emissions Determination Methods

Bottom-Up
Emission Source Parameters

- **Combustion Sources**
  - Cont. Emissions Monitors
    - Electrical Generation
    - Industrial Energy Production
  - Fuel Calculation method
    - Fuel Mass
    - Energy content - calorimetry
- **Area Sources – CH_4 & N_2O**
  - Agriculture, Nat. Gas system, Landfills
  - Emission – Activity Factor Model
    - System description based on experimental results generalized to specific sources
- **Focused on parameters directly associated with the emitting process**

Top-Down
Atmospheric Parameters

- **Tracer-transport methods**
  - Boundary Layer transport – mass flow
  - Mixing ratio measurements - concentration
- **Aircraft observations**
  - Direct Sampling
  - Remote Methods
- **Remote Sensing**
  - IR Spectroscopy Based
  - Satellite , airborne, and surface- based
- **Tracing GHG plumes back to their origin and estimating the flux strength at that point**

NIST Program Components

Urban Greenhouse Gas Dome Test Beds

- Stationary/Point Source Metrology
  - Stack Flow Measurement and Continuous Emission Monitoring Test Beds
- Distributed GHG Source Metrology
  - Advanced Measurement Systems for Urban Domes – Tools and Test Beds
    - Dense GHG Observing Networks – Measurements to Independently Diagnose GHG Emission Inventory Accuracy
    - Indianapolis Flux Experiment (INFLUX)
    - INFLUX Extensions to Megacity Test Beds
      - Los Angeles Megacity Carbon Project
      - Northwest Corridor Project
    - Development of an International Greenhouse Gas Metrology Framework Supporting Inventory Diagnosis and MRV
- GHG Measurements, Standards, Ref. Data, and Tools
  - GHG Concentration Standards
  - Spectroscopic Reference Data
  - Flux Measurement Tools
    - Differential Absorption Lidar Developments
  - Surface Air Temperature Assessment
- Climate Science Measurements - Advanced Satellite Calibration Standards
  - Optical and Microwave
- Black Carbon Aerosol Measurement Science
  - Optical Properties
  - Development of Reference Materials and Measurements

Tools and Test Beds for Diagnosing Greenhouse Gas Inventory Accuracy in U. S. Urban Domes

Developing and Assessing Performance of Greenhouse Gas Measurement Tools at Urban Scales

The Indianapolis Flux Experiment (INFLUX)

- *A Top-Down/Bottom-Up Greenhouse Gas Quantification Experiment in the City of Indianapolis, Indiana*

The LA Megacity Carbon Project

- *Estimating the Emissions Trends in a Megacity Having Complex Topography & Meteorology*

The Northeast Corridor

- *The Largest U.S. Megacity*
- *A Test Bed Having Moderately Complex Topography & Meteorology*
- *Initiation of The Effort Began in Mid-FY 14.*

A Step in the U.S. Towards an International Urban Greenhouse Gas Measurement Testbed Framework

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The Indianapolis Flux Experiment (INFLUX)

A Top-Down/Bottom-Up Greenhouse Gas Quantification Experiment

Objective: Develop measurement tools to provide independent verification of greenhouse gas inventories at urban and regional scales

- **Phase I – A GHG Mass Balance Experiment – Begun in early 2010**
  - NIST and university partners initiated the INFLUX (Indianapolis Flux) Experiment in 2010 as a Pilot project
  - Can the mass of CO_2 emitted by a small city be measured with quantified uncertainty using top-down and bottom-up methods?
  - Combined Aircraft and surface-based measurement methodology
  - High temporal and spatial resolution CO_2 inventory – Augmentation of EPA information
- **Phase II – Dense Observing Networks & Atmospheric Boundary Layer Transport Modeling**
  - Demonstrate measurement, characterization, and quantification of GHG Urban Domes and their dynamics utilizing a *Dense Measurement Network* approach coupled with aircraft observations :
  - A measurement method of demonstrated performance supporting the concepts of Measurable, Reportable and Verifiable (MRV) GHG Emissions and Removals
  - Demonstrate reconciliation methodologies for bottom-up (self-reported) inventory statements with top-down measurement results

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- **An Interdisciplinary Research Effort Advanced by Recent Technological Advances in:**
  - Real time measurements of greenhouse gas mixing ratios in the atmosphere,
  - Atmospheric boundary layer measurements and models,
  - GHG inventory determination at urban spatial scales, and
  - GHG plume inversion methodologies.
- **Quantitative Goals**
  - **Measure emission fluxes to within 10% or better**
  - **Identify major emitter locations within 1 km^2**

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The LA Megacity Carbon Project

Motivation:

Determine GHG emissions of a city in terms of measurement uncertainty.

Currently estimated differences between actual and reported emissions that by 50% or more when comparing inventory estimates with atmospheric measurements for a specific location, sector or gas.

Objective:

Demonstrate a scientifically-robust capability to measure multi-year *emission trends* of carbon dioxide (CO_2), methane (CH_4), and carbon monoxide (CO) attributed to individual megacities and selected major sectors.

Reduce uncertainty by jointly improving GHG emissions data and atmospheric observations.

Use independent and accurate measurements, identify error sources to improve emissions data quality and ultimately, validate basis for emission inventory.

Approach:

Use surface-based GHG observing network and aircraft observations coupled with state-of-the-art boundary layer measurements and characterization methods to observe emission trends in the South Coast Air Basin.

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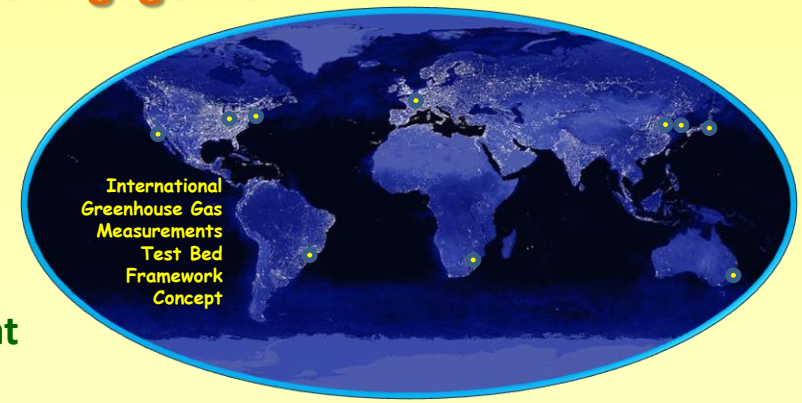
NIST Developmental Approach

NIST has some, but not all, technical capabilities to successfully address the urban measurement science research needed

- **Collaboration with organizations having expertise in:**
  - Observations of the atmosphere
  - Established standards systems not all directly associated with NIST
  - Atmospheric transport modeling capabilities
  - Measurement parameters that are not a mainstay of current NIST capabilities
    - Meteorological parameters
    - Wind speed and direction, surface energy flux, atmospheric boundary layer characterization and physics,
- **An organizational and funding challenge**
  - NIST directly funds university partners having the necessary expertise
  - NIST expertise, primarily in modeling, is being turned to the problem set as a 1st step toward developing institutional expertise
  - Gas Metrology is a fundamental capability
  - Funding of the original INFLUX experiment
  - Initial success with INFLUX led extension to a larger urban area
  - The Los Angeles region has significant existing capabilities
    - Jet Propulsion Laboratory, in-place air quality monitoring interests (California Air Resources Board and the South Coast Air Quality Management District), local universities, and private sector companies.
- **NIST as the U.S. NMI leads this measurement science challenge with the ultimate user agency(s) (e.g., U.S. EPA) having long-term responsible for stating the U.S. inventory**

International Greenhouse Gas Measurements Test Bed Framework

International Metrology & Climate Communities Engagement



Concept:

- **Establish an International Greenhouse Gas Measurements Test Bed Framework that:**
  - Enables joint development of advanced measurement capabilities for urban and regional GHG domes and their dynamics,
  - Establishes scientific validity and performance capabilities of advanced measurement methodologies and instruments,
  - Provides a focus for multi-organization efforts with locations and organization on all continents but Antarctica,
  - Facilitates open, internationally-recognized measurement methodology development and evaluation with open data exchange and utilization across national borders, and
  - Strengthens methods to correlate and calibrate satellite measurements in-situ with those made on the surface as a means to establish SI traceability
- **As the Basis for Global Recognition of Measurement Capabilities for:**
  - Diagnosing the quality of GHG emissions data and
  - Verification support for global Measurement, Reporting and Verification (MRV) concepts likely to be required by future international mitigation agreements

International Metrology & Climate Community Engagement

International Greenhouse Gas Measurement Test Bed Framework

Approach:

- **Joint development of urban GHG measurement methodologies utilizing population centers, megacities, as test bed sites**
- **Engage with nations or regions that have:**
  - **Suitably located megacities (one or two cities per continent/region)**
  - **The scientific and technological capabilities needed, and**
  - **The necessary national interest and will to commit the resources necessary**
- **Joint GHG measurement science research developing methodologies thoroughly vetted for their scientific foundation, accuracy, and recognition within the international community.**
- **Use existing Convention of the Mètre structures**
  - **Existing, internationally-recognized treaty organization with well-demonstrated working relationships and the necessary organizational structures largely in-place**
  - **Facilitates communication & organization**
  - **Broaden international linkages – WMO, international climate change/science**

Facilitating Organization Linkages

- Individual cities, Mayor Organizations
- International cities organizations
  - C40
  - ICLEI
- International Climate Organizations
  - WMO
  - GEO – Global Earth Observations
  - ICOS – International Climate Obs. Sys.

Challenges for NMIs & the NMI Community

- **Most NMI's currently may not have the necessary skill sets and connections**
  - **Partnering with national organization to aggregate the technical resources / expertise necessary to address this class of measurement science research**
  - **Strengthen expertise in climate science and related disciplines to successfully interface with both the national climate science community and the international community**

Thanks for your Attention